



Forest Sciences

Prince Rupert Forest Region

Extension Note # 42

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Donna Creek Washout-flow

Research Issue Groups:

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Wildlife Habitat

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Timber Harvesting

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Background

Donna Creek, a major tributary of Manson River, is located 75 km northwest of Mackenzie, B.C. (Figure 1). The washout-flow probably occurred over a few days, but was first observed on June 2, 1992 by Fletcher Challenge Canada Ltd. personnel, and on June 3, 1992 by B.C. Ministry of Forests and B.C. Ministry of Environment personnel.

Landform

The washout is situated on a terrace located at mid elevation on the east side of Donna Creek valley (Fig. 2). Elevation at the creek is 975 m and the hilltop above the washout 1450 m. The terrace rises steeply (35 to 40 degrees) above the floodplain. It is composed of glaciofluvial sands and gravels overlying glaciolacustrine sands and silts. A

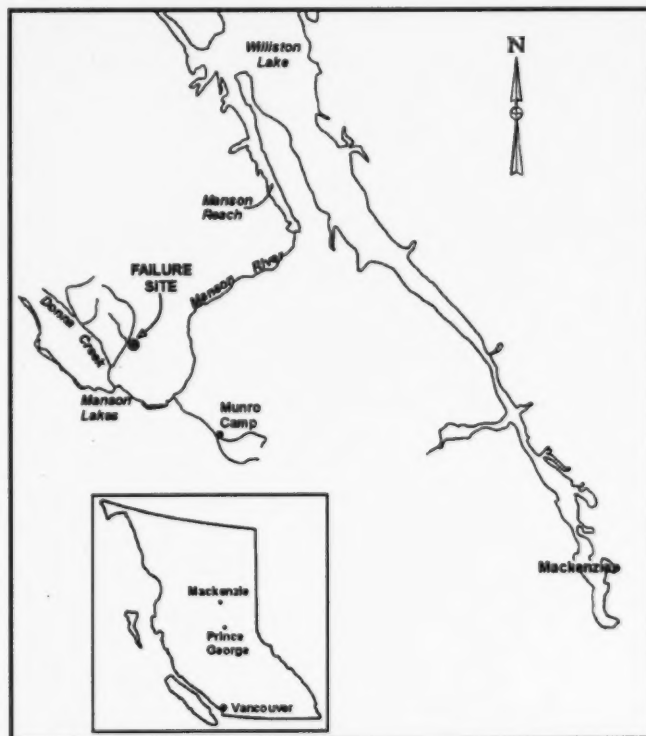


Figure 1. Donna Creek located northwest of Mackenzie B.C.

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thin discontinuous layer of compact glacial till covers a schist bedrock exposed in the scarp. Moderately fine textured morainal and colluvial materials mantle the surrounding slopes above the terrace.

Washout description

The crater eroded by the washout-flow is a large dendritic gully, 5 m deep at the headscarp with steep sidewalls extending up to 30 m deep (Figure 3). The gully covers a land area of approximately 4.5 ha, from which 422,500 m³ was

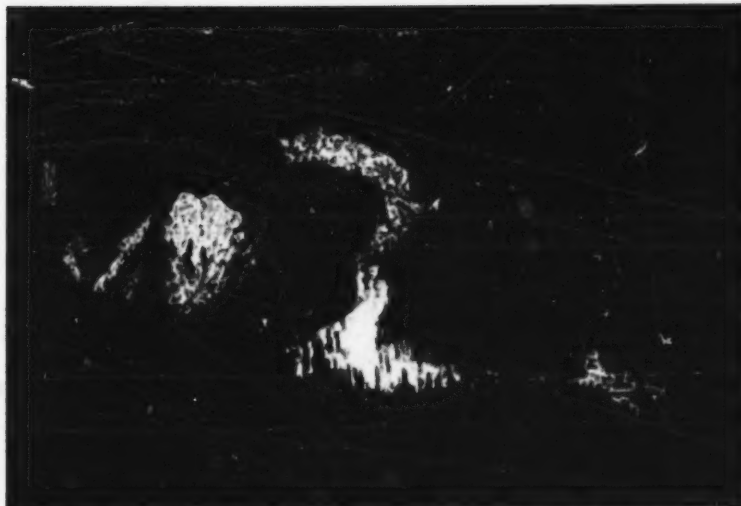


Figure 2. Washout-flow in photo centre. Note landform, roads on slope above and old slope failures along terrace scarp.

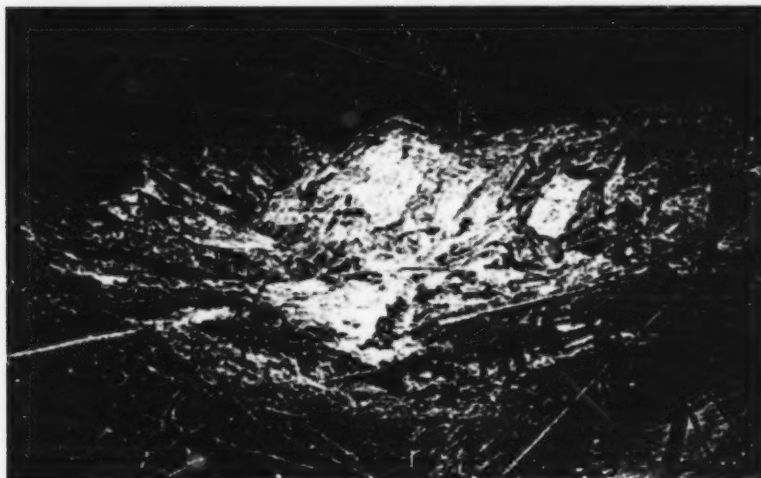


Figure 3. Washout looking into the gully from the headwall.



Figure 4. Debris fan on valley flat.

eroded. The eroded material was rapidly transported down the main gully to Donna Creek by debris flow surges. Destabilization of the main gully sidewalls resulted in the addition of a few thousand cubic meters of material to the volume of the flow. Approximately 62,500 m³ of debris and sediment were deposited on the fan where the main gully empties on to the valley flat. Few trees were left standing on the fan (Figure 4).

Sediment and debris (360,000 m³) that entered Donna Creek, combined with the spring freshet, triggered a debris flood that transported debris 6 km down Donna Creek toward Manson River. Large quantities of sediment were deposited and stored on the floodplain and temporarily stored behind the logjams within the stream channel.

Composite map

Figure 5 is a composite map of the Donna Creek slope failure, depicting topography, drainage basins, road locations, water flow directions and site locations (1, 2, 3, 4,

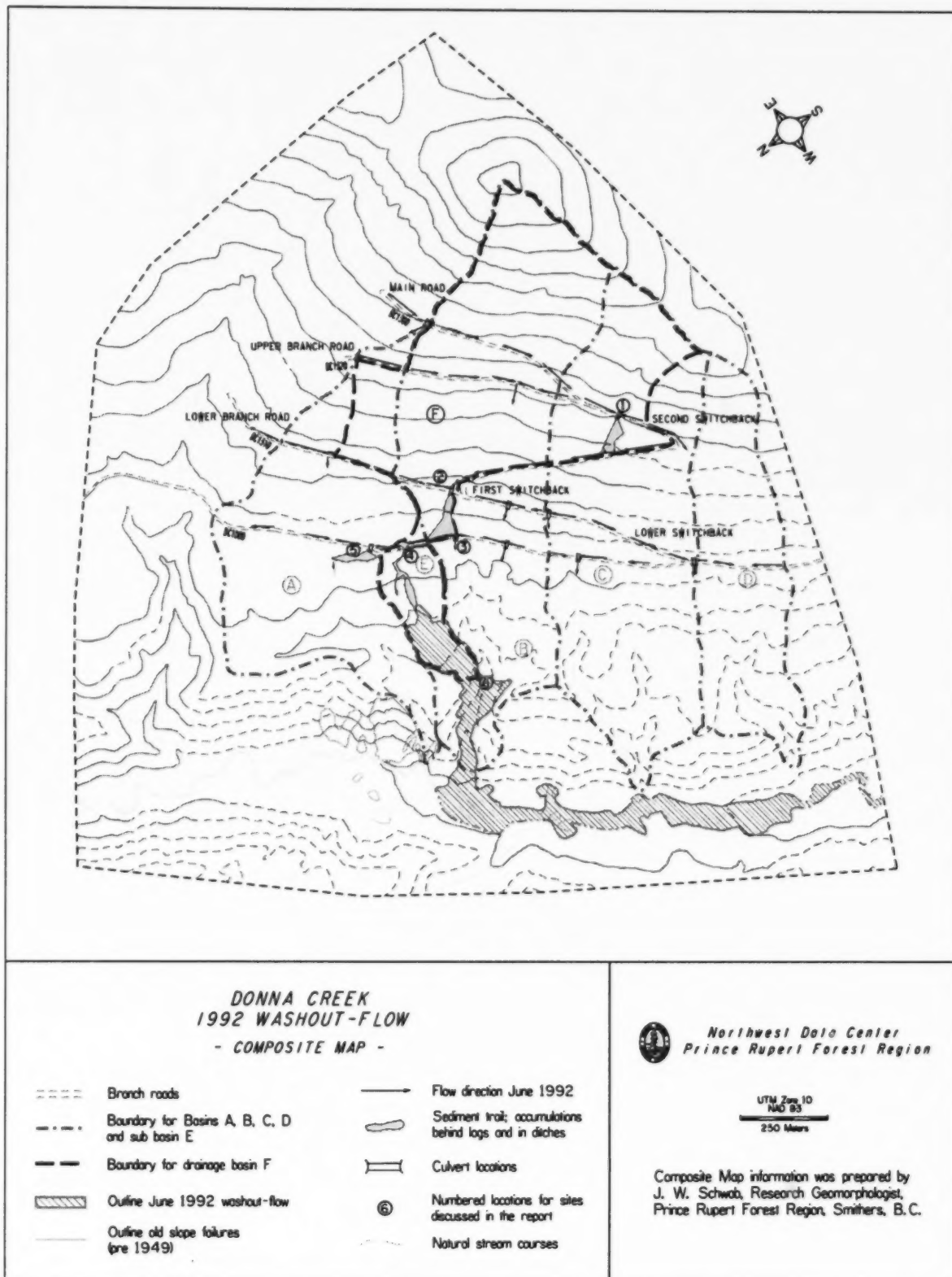


Figure 5. Composite map - Donna Creek 1992 Washout-flow.

5, and 6) referred to in the text.

Drainage basins

The established surface drainage on the hillslope above the Donna Creek washout occurs via four basins. The basins are poorly defined topographically on the steeper uniform slopes, but are well defined on the lower slopes by deeply incised gullies with outlets onto the Donna Creek valley flat. The basins designated as A, B, C, and D drain land areas of 39.3, 61.2, 49.5, and 24.4, ha, respectively. Basin E, a sub-basin of basin B, drains a land area of 5.8 hectares. Basin E is important in that its catchment encompasses the 1992 washout and drains into the main gully channel of basin B.

Road development

The hillslope above the washout was forested, with the exception of right-of-way cuts and roads constructed for timber harvesting. Construction of DC1000 branch road directly above the terrace started in 1988. Additional branch roads were constructed in 1990 to access a proposed cut block. Branch road DC1300 switchbacks up the slope to access the top of the proposed block. Further block access was obtained with mid-slope roads at lower and higher elevation DC1310 and DC1320, respectively.

Drainage alteration

The construction of DC1000 road dissected the natural drainage basins on the hillslope. A natural berm that formed the upper boundary for basin E was breached, during or sometime after construction, to permit water to



Figure 6. Ditch erosion, location #2.

flow from a low point on the road.

The DC1300 road contained four culverts (cross drains) over a distance of approximately 2,170 m. Two of the culverts were situated at lower elevations, along the road before the switchback at the DC1310 junction. Above the switchback, constructed drainage consisted of two culverts over a distance of approximately 1540 m. The steep-slope portion of the road, running from 11.2 to 16.8% grade, contained no cross drainage for approximately 700 m.

DC1310 contained one culvert placed close to the junction of the DC1300 road. DC1320 contained no culverts or constructed cross drainage.

The construction of DC1300, DC1310 and DC1320 in 1990 altered the natural drainage on the slope by collecting water along ditches and directing flow out of the natural drainage basins to outlet locations 1, 2, 3, 4, and 5 above the site of the 1992 washout. Erosion along ditches and a sediment trail mark the path of

water flow. This alteration of the hillslope drainage by the road network created a new drainage catchment that covered a land area of 56.9 hectares (basin F). This expanded drainage to the washout represents a catchment increase of 9.8 times (56.9 ha./5.8ha).

The major collection and channelization of water occurred along the DC1300 road above the second switchback, and further downhill along the steep section above the first switchback. The water eroded a deep channel in the ditch above the first switchback (Figure 6). Water was directed to a low spot on the DC1310 road (location 2). This filled the ditch and culvert with sediment. Then, water and sediment flowed over the road, overwhelmed the natural drainage channel below the road, and flowed overland down to the DC1000 road. The flow of sediment and water also overwhelmed the drainage constructed along the DC1000 road. The vast majority of water crossed the road via a cat push-out onto the terrain directly



Figure 7. Water delivered via the cat push-out, location #4.

above the washout (Figure 7).

Runoff

The hillslopes above Donna Creek experienced high rates of runoff from snow melt (May 25 to June 1, 1992). Flow determined using Manning equation for location 2 indicates a maximum flow of $0.31 \text{ m}^3/\text{s}$. This value compares to the modelled average daily value of $0.28 \text{ m}^3/\text{s}$ estimated for May 31, the date of the highest runoff at the site.

At peak flow, the volume of water delivered to the washout site via the cat push-out (Figure 7, location 4) was determined to be $0.23 \text{ m}^3/\text{s}$ —a daily total of $19,872 \text{ m}^3$ of water. This is equivalent to approximately 25 times the volume found in an average-size community swimming pool (800 m^3). The total volume of water delivered to the area above basin E from May 23 to June 2 was $193,631 \text{ m}^3$. An estimated 74% flowed to the washout site via the cat push-out. This equals $143,287 \text{ m}^3$ or 180 swimming pools over the 11 days. The estimated vol-

ume delivered was 7.3 times or 730% that received under natural conditions.

Erosion process

The large volume of surface water entering the site and the high infiltration rates of the gravelly sands permitted water to percolate through to depth. Thus, surface water added to the site greatly

increased the amount of water delivered to water-bearing layers (aquifers) in the complexly bedded sands, silts and gravels found within the glaciofluvial/glaciolacustrine materials. Through-flow of the subsurface waters appears to have concentrated above fine-textured stratigraphic layers, and over impermeable layers of compact till and bedrock. The subsurface bedrock gully also helped to concentrate flows toward the failure outlet. The exposure of a new face, possibly from a small failure on the terrace scarp (location 6) removed the plug or covering of the generally confined, water-charged aquifers within the complex glaciofluvial/glaciolacustrine deposit. Once a channel was established, it cut deeply into the highly erodible sands and silts, becoming a free face for piping failure and a locus for convergence of surface and subsurface flow.

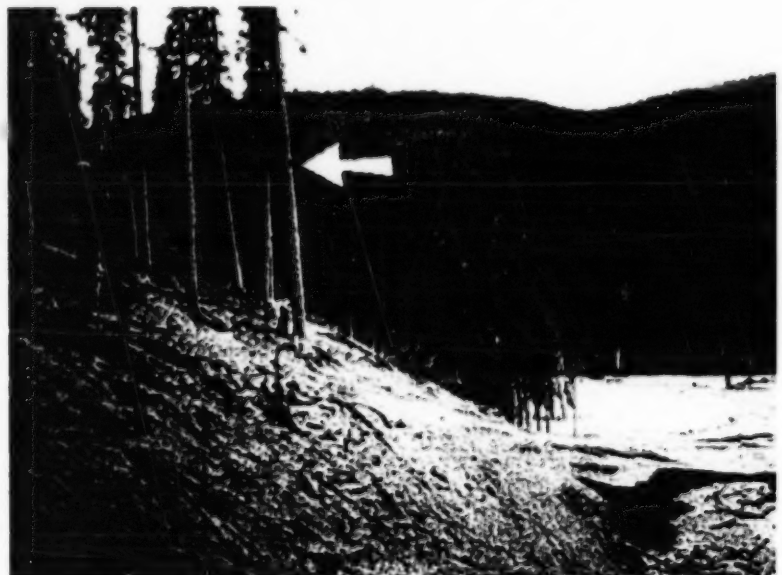


Figure 8. Debris flow splash, 10m high on trees (see arrow).

Flowing water is the driving force of the gully erosion process. At some point, the Donna Creek event reached a threshold where the erosional processes began to feed on each other: headward advance, piping or caving, collapse, and flow surges of liquefied material. Hence, the sudden apparent avulsion of material that was first noticed on the morning of June 2, 1992. Debris flow surges rapidly transported a large volume of material from the site, down the adjacent main gully channel, and subsequently down Donna Creek (Figure 8).

Large quantities of sediment and debris entering Donna Creek, combined with high spring runoff, triggered a debris flood: debris jam formation, breakage, and subsequent flow surges down the creek. Large volumes of sediment were deposited along the flood-plain and temporarily stored behind the logjams within the stream channel (Figure 9).

Summary

The 1992 Donna Creek washout-flow was caused by changes made to the natural hillslope runoff. The changes were a direct result of water capture and routing along road ditches. These roads did not have sufficient cross drainage or culverts to permit water to cross the roads and flow into natural drainage channels. Excessive volumes of water were delivered onto highly erodible sands, silts and gravels of a glaciofluvial/glaciolacustrine terrace. Erosion occurred progressively over a period of time, commencing during spring runoff 1990, and eventually culminating in the spectacular events of June 1992.



Figure 9. Debris flood down Donna Creek.

Suggested reading

- Dredge, L. A. and B. G. Thom. 1976. Development of a gully-flow near Sept-Iles, Quebec. *Can. J. Earth Sci.* 13:1145-1151.
- Hungr, O. and D. Smith. 1985. Landslides and development in the Lower Mainland, British Columbia. *The B.C. Professional Engineer* 36 (4):11-14.
- Williams, M. Y. 1966. The grand campus washout. *UBC Alumni Chronicle* 20:9-11.

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